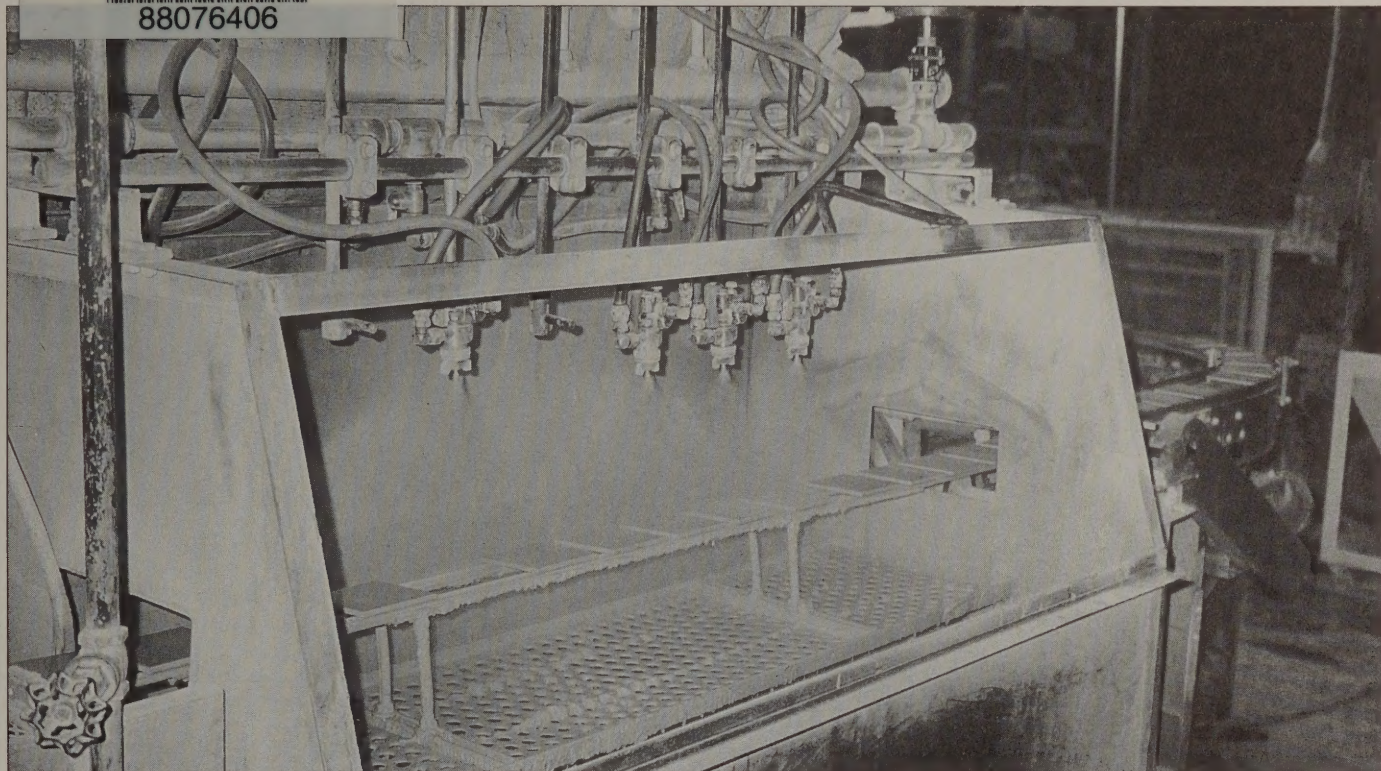


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ANNUAL REPORT



FELDSPAR, NEPHELINE SYENITE, AND APLITE

By Michael J. Potter

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FELDSPAR, NEPHELINE SYENITE, AND APLITE



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Manuel Lujan, Jr.
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Director

October 1991

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COVER PHOTO:

Feldspar and nepheline syenite are used as a flux and in glazes for whiteware such as tile. Fluxes lower the firing temperature of a ceramic body. A glaze (being sprayed onto tile in the photo) becomes a glassy coating after firing, which seals the ceramic surface and gives it a smooth, bright appearance. (Photo is courtesy of Wenczel Tile Co., Trenton, NJ.)

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FELDSPAR, NEPHELINE SYENITE, AND APLITE

By Michael J. Potter

Mr. Potter, a physical scientist with 24 years of industry and U.S. Bureau of Mines experience, has been the commodity specialist for feldspar since 1976. Domestic survey data were prepared by Linder Roberts, mineral data assistant; and international data table was prepared by Virginia Woodson, international data coordinator.

Feldspars are major components in most igneous rocks and constitute a large part of at least the outer layers of the Earth and its moon. Feldspar, usually of the potash or soda type or in mixtures of the two, finds its principal end uses in the manufacture of glass and ceramics. Feldspar acts as a flux and lowers the melting temperature of a ceramic mixture. In glassmaking, feldspar provides a source of alumina, which enhances the workability of the product and increases its chemical stability.

Feldspar consumption in glass containers and pottery remained flat during the first half of 1990 and decreased in the second half of the year. Feldspar use in glass containers has been affected by mergers and consolidation of glass manufacturers, increased use of recycled glass (cullet), and competition from imported nepheline syenite. Fewer housing starts in 1990 resulted in reduced feldspar demand in whiteware such as plumbing fixtures and tile.

The metric system is the official system of measurement of most countries. The U.S. Bureau of Mines, in an effort to provide statistical data on feldspar that are consistent with international usage, will henceforth report data in kilograms and metric tons unless otherwise noted.

DOMESTIC DATA COVERAGE

Domestic production data for feldspar are developed by the U.S. Bureau of Mines by means of a voluntary survey. Of the 13 active operations, 9 operations responded, representing 69% of the total

canvassed. These nine respondents reported a production of 474,000 tons or about 75% of the total domestic production shown in table 1. The estimated production of nonrespondents, 158,000 tons, was derived from past years' production levels and trends.

BACKGROUND

Definitions, Grades, and Specifications

Feldspar is the general term used to designate a group of closely related minerals, especially abundant in igneous rocks and consisting essentially of aluminum silicates in combination with varying proportions of potassium, sodium, and calcium. The principal feldspar types are orthoclase or microcline, both $K_2O \cdot Al_2O_3 \cdot 6SiO_2$, and anorthite, $CaO \cdot Al_2O_3 \cdot 2SiO_2$. Specimens of feldspar closely approaching these ideal compositions are seldom encountered in nature, however, and nearly all potash feldspars contain significant proportions of soda feldspar. Albite, or soda feldspar, and anorthite are the theoretical end members of a continuous compositional series known as the plagioclase feldspars, none of which is ordinarily without at least a minor admixture of potash. Commercially speaking, "potash spar" is feldspar containing 10% or more K_2O ; "soda spar" contains 7% or more Na_2O .

Perthite is the name given to material consisting of orthoclase or microcline and containing crystals that are intergrown with crystals of albite. Most of the feldspar of commerce can be classified most correctly as perthite.

Alaskite is a relatively coarse-grained,

granite-like feldspar ore that occurs in the Spruce Pine district of North Carolina. The principal mineral ingredients of this ore are approximately 45% plagioclase, 25% quartz, 20% microcline, and 10% muscovite mica. Minor amounts of other minerals are also present.¹ Beneficiated feldspar from alaskite is a major portion of total U.S. feldspar output.

Feldspar for glass manufacturing, ordinarily ground to 20 to 40 mesh, usually contains 4% to 6% K_2O , 5% to 7% Na_2O , and approximately 19% Al_2O_3 . Material for this purpose may be sold as a feldspar concentrate low in free quartz or in the form of a mixture containing feldspar and quartz with harmful impurities removed. In glass-grade feldspar, the iron content, expressed as Fe_2O_3 , is approximately 0.08% for high-quality clear glass. Typically, 70 to 90 kilograms of ground feldspar is used to produce 1 ton of container glass.

Feldspar with a high potash-to-soda ratio is often preferred for pottery making, and spar for this purpose is usually ground to minus 200 mesh. Potash spar ground to 120 or 140 mesh is usually specified for use in porcelain enamel, and even traces of such impurities as garnet, hornblende, tourmaline, and biotite mica ordinarily are not tolerated. Both potash and soda feldspars, ground to minus 200 mesh, are used in glazing.

Pottery-grade feldspar for whiteware and similar ceramic products may range from 5% to 14% in K_2O content and usually is ground to 200 mesh or finer. Limitations on iron content may be even more stringent than for glass grade; Fe_2O_3 content may be 0.07%. Feldspar for use in filler applications, such as for foam rubber products, may be similar to pottery spar in fineness of grind and

chemical composition, although more free quartz is often accepted; sometimes material for this purpose may be held to particle-size specifications expressed in micrometers.

Geology-Resources

Feldspar, one of the most abundant minerals in the Earth's crust, is found in significant amounts in some sedimentary strata and in nearly all igneous formations. Workable deposits of feldspar are probably widely distributed throughout most of the world, and the total quantity of the mineral potentially available is very large.

It has been estimated that feldspar constitutes 60% of all crystalline igneous rocks. Granted sufficient demand and economic incentive, the mineral could be extracted from the world's granite, a source that is extremely large.

Data are not available on the quantity of feldspar in either domestic or foreign deposits. However, U.S. reserves are estimated to be quite large in the Spruce Pine district of North Carolina alone.

Feldspar concentrations of potential economic interest exist in many pegmatites, granites, and other granitic rocks and as accumulations of certain residual sands on ocean beaches or river banks.

Pegmatites are masses of coarsely crystalline rocks of igneous origin. Pegmatite bodies may range in size from small pods to extensive formations measuring hundreds or even thousands of feet. The principal feldspar ore bodies of pegmatitic type currently being exploited in the United States are in Connecticut, Georgia, North Carolina, and South Dakota. Potentially exploitable pegmatite bodies are known to exist in other areas.

The only feldspathic sand deposits now being mined in the United States are in California, Idaho, and Oklahoma. Other accumulations of feldspathic sands in the United States offer possibilities as future sources of feldspar supply.

Granites are widely distributed igneous rocks of plutonic origin. Granites are present as major components of whole mountain ranges, and the dimensions of granite bodies can often be stated in miles. The important constituent minerals in granites are much the same as those in pegmatites, although there are likely to be significant differences in the respective proportions. Because of economic and technologic considerations, commercial utilization of granite in the United

States as a source of feldspar is not presently taking place.

Technology

Most feldspathic rocks can be quarried by open pit procedures. High-grade, selectively mined feldspar from pegmatites may be dry processed, passing consecutively through jaw crushers, rolls, and pebble mills before being subjected to high-intensity magnetic or electrostatic treatment to bring the iron content down to an acceptable level.

The customary procedure applied to most massive deposits, such as alaskite, begins with drilling, blasting, and drop-ball breaking at the quarry, followed by primary and secondary crushing and fine grinding in jaw crushers, cone crushers, and rod mills, respectively. The sequence typically continues with acid-circuit flotation in three stages, each stage preceded by desliming and conditioning. The first flotation step typically depends on an amine collector to float off and remove mica, and the second uses sulfonated oils to separate iron-bearing minerals, most notably garnet. The third step, flotation with another amine collector, leaves behind a residue that consists chiefly of quartz. Sometimes the third step is bypassed, leaving a feldspar-silica mixture, which can be used with little or no additional processing as furnace-feed ingredients in the manufacture of glass.

The flotation-cake feldspar or feldspar-silica mixture is dewatered in filters or drain bins and dried in rotary driers for use as glass-grade feldspar. Some material is further ground in pebble mills as pottery spar and for other uses.

Byproducts and Coproducts

Feldspar was obtained as a coproduct in 1990 from two companies mining and processing lithium ores and one company treating weathered pegmatite ore containing mica and kaolin. Coproduct recovery of mica and silica sand was reported by some feldspar processors.

Economic Factors

Feldspar is largely sold in bulk and moved by rail hopper cars. Transportation can comprise 50% or more of the total delivered cost. Some shipments are by truck. Most feldspar products are shipped less than 1,000 miles. An exception is premium-grade high-potash feldspar.

ANNUAL REVIEW

Feldspar

Legislation and Government Programs.—According to provisions of the Tax Reform Act of 1969, which continued in force throughout 1990, the depletion rate allowed on domestic and foreign feldspar production was 14%.

Production.—Feldspar or feldspar-silica sand was mined in seven States, led by North Carolina and followed, in descending order, by Connecticut, California (estimated), Georgia, Oklahoma, Idaho, and South Dakota. North Carolina accounted for 66% of the total. Eleven U.S. companies operating 13 beneficiating plants and 1 grinding plant produced feldspar or feldspar-silica mixtures for shipment to more than 31 States and foreign countries, including Canada and Mexico. Of the 11 companies, 3 produced potash feldspar, and the remainder produced soda and/or potash feldspar or feldspathic sand mixtures. North Carolina had six plants, California had two, and Connecticut, Georgia, Idaho, Oklahoma, and South Dakota each had one. The grinding plant was in South Carolina.

The U.S. Bureau of Mines uses a criterion of 8% minimum K_2O content in collecting data for potash feldspar.

In late 1990, the two feldspar mines and processing plant in Spruce Pine, NC, owned by Indusmin Inc., were sold to Hecla Mining Co. The new name of the operation was KT Feldspar Corp.

Consumption and Uses.—Of the total feldspar sold or used in the United States, 56% went into glassmaking, including container glass and glass fiber, and 44% was used in pottery and other applications. Fewer housing starts in 1990 resulted in decreased feldspar usage in plumbing fixtures and tile compared with that of the previous year.

Processed feldspar is added to glass-making formulas for its alumina and alkali contents. Alumina enhances the workability of molten glass and improves the finished product by giving it better chemical stability. The increased workability facilitates the operation of automatic machines for shaping jars and bottles. Greater chemical stability broadens the usefulness of the containers. Feldspar is used in ceramic mixtures, such as those for the making of vitreous

TABLE 1
SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS

		1986	1987	1988	1989	1990
United States:						
Feldspar:						
Produced ¹	metric tons	665,000	655,000	650,000	655,000	630,000
Value	thousands	\$26,100	\$26,100	\$26,400	\$28,000	\$27,400
Exports	metric tons	10,886	8,740	12,439	9,329	24,795
Value	thousands	\$1,024	\$691	\$769	\$829	\$2,167
Imports for consumption	metric tons	1,135	4,384	6,193	12,003	11,318
Value	thousands	\$542	\$477	\$659	\$873	\$723
Nepheline syenite:						
Imports for consumption	metric tons	271,072	280,034	281,086	303,000	276,000
Value	thousands	\$11,280	\$11,401	\$11,233	\$12,273	\$12,200
Consumption, apparent ² (feldspar plus nepheline syenite)						
	thousand metric tons	928	929	924	961	895
World: Production (feldspar)	do.	^r 4,115	^r 4,410	^r 4,899	^r 5,176	^e 5,023

^eEstimated. ^pPreliminary. ^rRevised.

¹Includes hand-cobbed feldspar, flotation-concentrate feldspar, and feldspar in feldspar-silica mixtures; includes potash feldspar (8% K₂O or higher).

²Production plus imports minus exports.

TABLE 2
FELDSPAR¹ PRODUCED IN THE UNITED STATES

(Thousand metric tons and thousand dollars)

Year	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures ²		Total ³	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1986	12	W	474	19,855	181	W	665	26,100
1987	10	W	446	17,800	199	W	655	26,100
1988	13	W	452	18,657	185	W	650	26,400
1989	11	W	425	16,915	219	W	655	28,000
1990	W	W	437	15,815	W	W	630	27,400

W Withheld to avoid disclosing company proprietary data; included in "Total."

¹Includes potash feldspar (8% K₂O or higher).

²Feldspar content.

³Data may not add to totals shown because of independent rounding.

china and porcelain enamels, principally as a flux. It fuses at a temperature below the melting point of most of the other ingredients. It also performs as a vitreous binder to cement particles of various crystalline substances present in ceramic mixtures. Feldspar serves advantageously in abrasives and scouring soaps. It forms a mild abrasive but is soft enough to avoid injury to the article being cleaned. Feldspar is also used as a filler in paint, foam rubber, and plastics.

The quantity of potash feldspar sold or used in 1990 was 60,600 tons with a value of \$5.8 million.

Whiteware is a significant end use of feldspar. In 1989, sanitaryware sales were 44% of total whiteware sales; floor and wall tile were 33%.² The mix for sanitaryware bodies is about 50% clay (ball clay and kaolin), 25% silica, and 25% feldspar or nepheline syenite. A typical glaze may contain about 30% feldspar and smaller proportions of several other ingredients.³

World Review.—Capacity.—The data in table 10 are rated capacity for mines and refineries as of December 31, 1990. Rated capacity is defined as the

maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Because actual capacity data were not available, recent peak production during the past 5 years for the United States

TABLE 3

PRODUCERS OF FELDSPAR AND FELDSPATHIC MATERIALS IN 1990

Company	Plant location	Product
APAC Arkansas Inc.	Muskogee, OK	Feldspar-silica mixture.
CISCO	Corona, CA	Do.
Cyprus Foote Mineral Co.	Kings Mountain, NC	Do.
The Feldspar Corp.	Middletown, CT	Soda-potash feldspar.
Do.	Monticello, GA	Potash feldspar.
Do.	Spruce Pine, NC	Soda-potash feldspar.
Do.	Montpelier, VA	Aplite.
Indusmin Inc.	Spruce Pine, NC	Soda-potash feldspar.
KMG Minerals, Inc.	Kings Mountain, NC	Potash feldspar.
Lithium Corp. of America	Bessemer City, NC	Feldspar-silica mixture.
Pacer Corp.	Custer, SD	Potash feldspar.
Spartan Minerals Corp.	Pacolet, SC	Feldspar-silica mixture.
Unimin Corp.	Emmett, ID	Do.
Do.	Spruce Pine, NC	Soda-potash feldspar.
U.S. Silica Co.	Oceanside, CA	Feldspar-silica mixture.

TABLE 4

FELDSPAR¹ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE

(Thousand metric tons and thousand dollars)

Use	1989		1990	
	Quantity	Value	Quantity	Value
Hand-cobbed:				
Pottery	5	W	W	W
Other	5	W	W	W
Total ²	9	W	W	W
Flotation concentrate:				
Glass	166	7,009	162	7,270
Pottery	261	15,717	234	14,178
Total ²	426	22,726	395	21,448
Feldspar-silica mixtures: ³				
Glass	183	10,716	175	10,617
Pottery	23	W	W	W
Total ²	206	W	W	W
Total: ²				
Glass ⁴	348	17,725	337	17,887
Pottery	289	W	W	W
Other ⁵	5	W	W	W
Total	640	35,900	600	34,100

W Withheld to avoid disclosing company proprietary data; included in "Total."

¹Includes potash feldspar (8% K₂O or higher).²Data may not add to totals shown because of independent rounding.³Feldspar content.⁴Includes container glass and glass fiber.⁵Includes enamel, filler, etc., and unknown.

and foreign countries was considered to be equal to rated capacity.

Australia.—The domestic market of 10,000 tons per year was largely in the ceramic and welding rod manufacturing industries. The market was mainly on the eastern coast in Victoria and New South Wales.

The Mukinbudin pegmatite deposit owned by Commercial Minerals Ltd. was one of two major Australian feldspar operations. The mainly quartz-microcline (potash) feldspar deposit is near the town of Mukinbudin, which is 330 kilometers east of Perth, the capital of Western Australia. The quartz was crushed and screened as a decorative stone for the local building industry. The feldspar was crushed and shipped to clients or mills for further processing. Chemical analysis of the material was 11.5% K₂O, 2.6% Na₂O, and 0.1% Fe₂O₃. Both lump ore and milled feldspar were exported from the port city of Perth to Southeast Asia. Iron contents of 0.08% were achieved by processing selected high-grade ore; in 1990, a magnetic separation plant was being installed to produce feldspar with 0.04% Fe₂O₃ for use in glazes.

The country's second major deposit was the Pippingarra pegmatites, also owned by Commercial Minerals, 30 kilometers from Port Hedland on the northwest coast. The massive microcline feldspar deposit also contained muscovite mica, which was processed and sold for oil well drilling and other uses. An extensive drilling program was planned for early 1990 to delineate ore reserves. This deposit is well situated to serve the Southeast Asia market area.

Potash feldspar is not widely available in Asia, and a significant market for high-quality material exists in Japan, Korea, and Taiwan. The ceramic tile industry of Taiwan was reported to be the third largest in the world after Italy and Spain. Another outlet for potash feldspar in Southeast Asia was in welding rod manufacture for the heavy construction industry. The potash spar is able to improve the surface finish of the weld. Other end uses were in the television tube and neon tube glass industries.⁴

Nepheline Syenite

Nepheline syenite was produced by Indusmin Ltd., a division of Falconbridge Ltd., from two operations at Blue

TABLE 5

DESTINATION OF SHIPMENTS OF FELDSPAR¹ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE

(Metric tons)

State	1986	1987	² 1988	³ 1989	⁴ 1990
Alabama	18,200	W	W	W	W
California ^c	45,400	45,400	45,400	68,000	61,900
Florida	18,100	12,900	W	W	W
Georgia	82,200	78,500	84,500	74,400	66,800
Illinois	25,300	26,000	26,900	24,900	24,000
Indiana	W	W	27,300	25,400	23,800
Kentucky	15,300	W	15,400	14,700	12,700
Louisiana	12,800	13,500	12,600	10,900	9,100
Maryland	6,400	5,800	6,500	7,600	7,200
Mississippi	W	W	12,000	10,400	W
Missouri	5,500	4,700	4,400	W	4,100
North Carolina	18,800	36,700	21,500	18,100	15,700
Ohio	61,900	58,400	58,700	52,300	46,600
Pennsylvania	30,500	33,000	26,500	34,800	29,800
Texas	40,800	39,900	W	W	W
West Virginia	22,100	18,000	17,000	16,800	15,500
Other ⁵	262,500	277,600	301,600	285,600	281,900
Total ⁶	666,000	650,000	660,000	644,000	599,000

^cEstimated. W Withheld to avoid disclosing company proprietary data; included with "Other."¹Includes potash feldspar (8% K₂O or higher).²An estimated 68% of these data were obtained by survey forms; the remaining 32% were estimated.³Because of a lack of actual data, an estimated 65% of these data were obtained from projections of previous years' data.⁴Because of a lack of actual data, an estimated 67% of these data were obtained from projections of previous years' data.⁵Includes Arkansas, Colorado, Connecticut, Kansas, Michigan, Minnesota, Oklahoma, Rhode Island, Tennessee, Virginia, States indicated by symbol W, and unspecified States. Also includes exports to Canada, Mexico, and other foreign countries.⁶Data may not add to totals shown because of independent rounding.

TABLE 6

DESTINATION OF SHIPMENTS OF POTASH FELDSPAR¹ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE

(Metric tons)

State	1986	1987	1988	1989	1990
Illinois, Indiana, Wisconsin	5,000	W	W	W	W
Maryland, New York, West Virginia	23,200	W	W	W	26,700
Ohio	W	W	W	W	W
Pennsylvania	W	W	W	W	W
Texas	300	W	W	W	W
West Virginia	3,200	W	W	W	W
Other ²	35,500	W	W	W	W
Total	67,200	W	85,700	73,000	60,600

W Withheld to avoid disclosing company proprietary data; included with "Other."

¹K₂O content of 8% or higher.²Includes Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Kansas, Kentucky, Louisiana, Michigan, Massachusetts, Minnesota, Missouri, New Jersey, North Carolina, South Carolina, Tennessee, Virginia, States indicated by symbol W, and other unspecified States. May also include countries.

Mountain and Nephton, Ontario, Canada. Output in 1989, the latest year for which information was available, was estimated to be more than 660,000 tons. End uses included glass, whiteware, and as a filler and extender in paint, plastic, adhesives, and rubber.⁵ In late 1990, Unimin Corp. of New Canaan, CT, acquired the Indusmin nepheline syenite operations. The new name of the company was to be Unimin Canada Ltd.⁶

In Norway, nepheline syenite was produced at the Elkem Nefelin A/S, underground mining operation on the arctic island of Stjernøy. Output was 287,000 tons in 1988, the latest year for which data were available. Sales were largely to markets in Western Europe.⁷

Prices for Canadian nepheline syenite listed in Industrial Minerals (London), December 1990, were approximately \$24 to \$31 per ton for glass grade, 30 mesh, bulk, carlots-trucklots, depending on iron content; \$74 per ton for ceramic grade, 200 mesh, bagged, 10-ton lots; and \$87 to \$100 per ton for filler-extender grade, bagged.

Aplite

Aplite is a feldspar mineral that has more than one geological definition. However, apfite from the one active U.S. operation contains lime-soda feldspar. Aplite, usually unsuitable for use in ceramics, has been used in the manufacture of glass when it is sufficiently low in iron.

Aplite of glassmaking quality was produced in the United States by The Feldspar Corp. near Montpelier, Hanover County, VA.

Domestic output was approximately the same as in 1989. The data are company proprietary and cannot be released for publication. Aplite traditionally has a somewhat lower price than feldspar. Industrial Minerals (London), December 1990, gave a value of \$25.75 per ton for glass grade, bulk, 100% plus 200 mesh, f.o.b. Montpelier, VA.

With an annual production of 500,000 tons to 560,000 tons in recent years, Japan has been the world's largest producer of apfite. Italy is the world's largest producer of feldspathic materials, including feldspar and apfite; published figures did not give the relative breakdown of the two minerals.

TABLE 7
PRICES FOR FELDSPAR

(Dollar per metric ton, f.o.b. plant, bulk)

Producing States	1989	1990
Ceramic grade:		
Middleton, CT, minus 200 mesh	74.41	74.41
Monticello, GA, 200 mesh, high potash	90.94	90.94
Spruce Pine, NC, 170 to 250 mesh	55.12	55.12
Glass grade:		
Middleton, CT, 96% plus 200 mesh	50.16	50.16
Monticello, GA, 92% plus 200 mesh, high potash	71.38	71.38
Spruce Pine, NC, 97.8% plus 200 mesh	35.83	36.93

Source: Industrial Minerals (London), No. 267, Dec. 1989, p. 74, and No. 279, Dec. 1990, p. 78.

TABLE 8
U.S. EXPORTS OF FELDSPAR, BY COUNTRY

Country	1988		1989 ¹	
	Metric tons	Value	Metric tons	Value ²
Canada	2,011	\$146,955	2,558	\$273,133
Dominican Republic	293	22,433	326	71,869
Germany, Federal Republic of	—	—	1,878	142,491
Italy	888	74,680	1,796	242,398
Mexico	2,043	172,329	1,536	236,668
Netherlands	—	—	14,075	829,743
Taiwan	1,090	154,261	238	72,316
United Kingdom	—	—	710	75,255
Venezuela	748	59,898	238	9,262
Other	2,256	198,440	769	213,647
Total	9,329	828,996	24,795	2,166,782

Source: Bureau of the Census.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF FELDSPAR, BY COUNTRY

Country	1989		1990	
	Metric tons	Value ¹	Metric tons	Value ¹
Germany, Federal Republic of	29	\$8,241	69	\$22,142
Mexico	11,974	864,407	11,249	700,638
Total	12,003	872,648	11,318	722,780

¹ Customs value.

Source: Bureau of the Census.

TABLE 10
WORLD FELDSPAR ANNUAL
PRODUCTION CAPACITY,
DECEMBER 31, 1990

(Thousand metric tons)

	Rated capacity ¹
North America:	
Mexico	130
United States	665
Total	795
South America:	
Brazil	121
Venezuela	100
Other	142
Total	363
Europe:	
Finland	56
France	360
Germany, Federal Republic of	315
Italy	1,368
Norway	90
Poland	57
Portugal	66
Romania ^c	86
Spain	196
Sweden	40
U.S.S.R. ^c	330
Yugoslavia	50
Other	16
Total	3,030
Africa:	
South Africa, Republic of	82
Other	36
Total	118
Asia and Oceania:	
India	58
Japan	58
Korea, Republic of	242
Thailand	520
Turkey	100
Other	67
Total	1,045
World total ²	5,350

^c Estimated.

¹ Includes capacities of operating plants as well as plants on stand-by basis.

² Data do not add to total shown because of independent rounding.

TABLE 11
FELDSPAR: WORLD PRODUCTION, BY COUNTRY¹

(Metric tons)

Country ²	1986	1987	1988	1989	1990 ^e
Argentina	24,087	29,282	39,469	23,688	24,000
Australia	10,006	11,499	15,877	^r e15,000	16,000
Austria	2,850	4,692	8,222	7,251	7,300
Brazil ³	120,572	118,608	109,534	^e 120,000	120,000
Burma	2,861	1,916	2,626	^e 2,500	2,500
Chile	2,275	705	4,569	^r 8,173	8,000
Colombia	35,722	33,760	37,136	^r 40,850	40,000
Ecuador	2,298	1,558	^r 5,000	^r 22,576	8,000
Egypt	19,287	15,963	6,131	^r 27,731	27,000
Finland	47,049	51,632	^r 56,200	54,581	55,000
France	216,000	274,000	^r 322,000	^r 360,000	300,000
Germany, Federal Republic of:					
Western states	247,498	310,447	308,776	^r e310,000	315,000
Guatemala	5,446	7,669	^e 7,200	^e 7,000	7,000
Hong Kong	35,208	22,853	^r 11,050	^r 5,152	4,000
India	^r 48,264	49,663	^r 57,656	^r 56,690	58,000
Iran ^e	32,000	32,000	32,000	32,000	32,000
Italy	^r 1,237,058	1,188,700	1,367,776	^r 1,350,733	1,300,000
Japan ⁴	32,063	33,754	29,465	43,137	58,300
Kenya	—	—	—	^r 1,112	1,000
Korea, Republic of	130,895	180,269	241,511	^r 232,607	230,000
Mexico	85,019	106,490	^r 83,170	^r 121,988	130,000
Morocco ^e	1,000	1,000	1,000	1,000	1,000
Mozambique ^e	100	—	—	—	—
Nigeria	2,418	485	190	945	900
Norway ^{e 5}	^e 87,257	^r 90,000	^r 90,000	^r 90,000	90,000
Pakistan	11,575	6,675	9,026	^r 7,703	8,000
Peru	19,467	64,749	^e 20,000	^e 20,000	20,000
Philippines	6,661	11,996	9,199	^e 6,000	8,000
Poland	57,200	55,000	^e 50,000	^e 50,000	50,000
Portugal	33,740	40,729	^r 51,903	^r 65,854	60,000
Romania ^e	86,000	82,000	82,000	75,000	70,000
South Africa, Republic of	52,762	66,513	81,889	^r 56,220	^e 56,124
Spain ⁷	135,526	161,631	^r 195,668	^r e155,000	150,000
Sri Lanka	7,270	7,442	6,345	6,656	6,800
Sweden	35,160	34,226	^r e36,000	^e 40,000	40,000
Taiwan	26,290	28,116	19,101	^r 9,806	7,380
Thailand	115,163	168,881	293,678	^r 515,206	520,000
Turkey	12,180	30,336	^r 82,225	^r 90,751	100,000
U.S.S.R. ^e	330,000	330,000	330,000	330,000	300,000
United Kingdom (china stone)	7,304	5,692	6,267	6,470	6,500
United States	^r 665,000	^r 655,000	650,000	655,000	^e 630,000
Uruguay	^r 1,632	^r 3,016	^r 2,787	^r 2,680	3,000
Venezuela	34,900	43,546	96,500	^r 97,000	100,000
Yugoslavia	47,909	44,912	35,615	^r 49,000	50,000

See footnotes at end of table.

TABLE 11—Continued

FELDSPAR: WORLD PRODUCTION, BY COUNTRY¹

(Metric tons)

Country ²	1986	1987	1988	1989 ^p	1990 ^e
Zambia	214	45	120	20	50
Zimbabwe	2,026	2,962	3,730	2,697	2,500
Total	^r 4,115,212	^r 4,410,412	4,898,611	5,175,777	5,023,354

^eEstimated. ^pPreliminary. ^rRevised.¹Table includes data available through Apr. 19, 1991.²In addition to the countries listed, Czechoslovakia, Madagascar, and Namibia produce feldspar, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.³Series excludes production of leucite and sodalite; data consist only of that material reported by Brazil under the heading of "Feldspar." Data represent the sum of (1) run-of-mine production for direct sale, and (2) salable beneficiated product; total run-of-mine feldspar production was as follows, in metric tons: 1986—105,042; 1987—98,828; 1988—140,041; 1989—140,000 (revised, estimated); and 1990—140,000 (estimated).⁴In addition, the following quantities of aplite concentrate were produced in metric tons: 1986—457,375; 1987—466,429; 1988—526,285; 1989—562,823; and 1990—517,000 (estimated).⁵Excludes nepheline syenite.⁶Reported figure.⁷Includes pegmatite.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF NEPHELINE SYENITE

Year	Crude		Ground	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1988	2,615	\$111	278,471	\$11,122
1989 ¹	—	—	303,000	12,273
1990 ¹	—	—	276,000	12,200

¹Crude and ground combined for 1989 and 1990.

Source: Bureau of the Census.

OUTLOOK

U.S. feldspathic consumption has remained fairly constant for the past several years. Competition from imported nepheline syenite, as well as increased use of recycled glass (cullet) and lightweighting of glass containers, have impacted on the demand for feldspathic materials in glass manufacturing. Glass containers should at least maintain their market share in the near future in a field that includes metal cans and plastic containers.

Fewer housing starts in recent years have resulted in static feldspar demand in whiteware such as plumbing fixtures and tile and in glass fiber insulation for housing. Feldspar outlook in 1991 will be

affected, in part, by the level of construction activity and remodeling.

¹Rogers, C. P., Jr., and J. P. Neal. Feldspars. Ch. in Industrial Minerals and Rocks, rev. by K. H. Teague. AIME, New York, 5th ed., 1983, p. 711.

²Ceramic Industry. Giants in Whiteware. V. 135, No. 2, Aug. 1990, p. 36.

³Burger, J. The U.S. Sanitaryware Industry. Ind. Miner. (London), No. 277, Oct. 1990, p. 54.

⁴Toye, C. Quality Feldspars From Western Australia Going International. Paper from 9th "Industrial Minerals" International Congress, ed. by J. B. Griffiths (Proc. Conf. Sydney, Australia, 1990, Mar. 25–28, 1990). Metal Bulletin PLC, 1990, pp. 47–52.

⁵Taylor, G. H. Nepheline Syenite. Am. Ceram. Soc. Bull., v. 69, No. 5, May 1990, p. 873.

⁶Ceramic Industry. Unimin Acquires Silica Plants. V. 135, No. 5, Nov. 1990, p. 16.

⁷Neilsen, K. Norway, Small in Size—Large in Non-metallic Minerals. Paper from Second World Congress on Non-metallic Minerals, Beijing, China, Oct. 17–21, 1989, pp. 453, 455–456.

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